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RESEARCH NOTE RM-368

FOREST SERVICE
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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Energy Potential from Central and Southern Rocky Mountain Timber[1]

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Low energy per unit of weight and high cost relative to coal limit wood as a major energy source in the central and southern Rocky Mountains. Without markets for higher uses, residues can provide heat, steam, or electricity. Uses will depend on improved technology and harvest efficiency.

Keywords: Energy, timber residues

Introduction

It might be supposed potential is fairly high for utilizing wood for energy in the central and southern Rocky Mountain states (South Dakota, Wyoming, Colorado, Arizona, and New Mexico). Forest land area per resident is high compared to the remainder of the United States. Figure 1 shows total area of forest land and commercial forest land for each state involved. Forest land is land at least 16.7% stocked by forest trees of any size or formerly having such tree cover and not currently developed for non-forest use. Commercial forest land is forest land not withdrawn from timber utilization and having the capability of producing more than 20 cubic feet of wood per acre (1.4 m^3/h) per year. Commercial forest land represented in figure 1 includes currently inaccessible and inoperable areas as well as qualifying areas examined under the Forest Service Roadless Area Review and Evaluation II (RARE II). Not inlcuded in commercial forest land are existing Wilderness Areas, National Parks, and other permanently reserved areas. Areas of commercial forest land within National Forests are shown in figure 1.

Energy Potential with Maximum Growth

Theoretically, the maximum sustainable energy production of central and southern Rocky Mountain commercial forest lands is directly determined by sustainable wood growth under maximum forest production. Current growth levels on commercial forest lands are much lower than potential growth. Nevertheless, annual removals are well below actual growth, except in Arizona.

Traditional growth data is based only on the bole of trees. Since branches, tops, and needles can be utilized for energy, the estimate of sustainable energy potentials derived in this study (fig. 2) includes a 40% increase over bole volume. The resulting cubic foot volume was multiplied by 25 to convert to dry weight in pounds per green cubic foot (25 was arbitrarily

[1]Presented at the Colorado State University Natural Resource Days, March 10, 1978, in Fort Collins.

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chosen to represent the average of Rocky Mountain timber species, which range from 20 to 29 pounds dry weight per green cubic foot). This weight was then converted to British Thermal Unit (BTU) equivalents by multiplying by 8,500 (8,500 BTU's per pound of dry wood is an energy conversion factor in general use). Table 1 shows typical heating values for wood and bark of Rocky Mountain species. The energy equivalent of this total timber harvest is compared with the estimated energy consumption by state in figure 3 (consumption does not include firewood and other minor energy sources such as animal wastes). Consumption estimates were derived from national estimates by using the proportion of population in each state to national population as a basis (Baldwin et al. 1974). The total potential energy available from wood is less than 15% of combined annual energy consumption in these states.

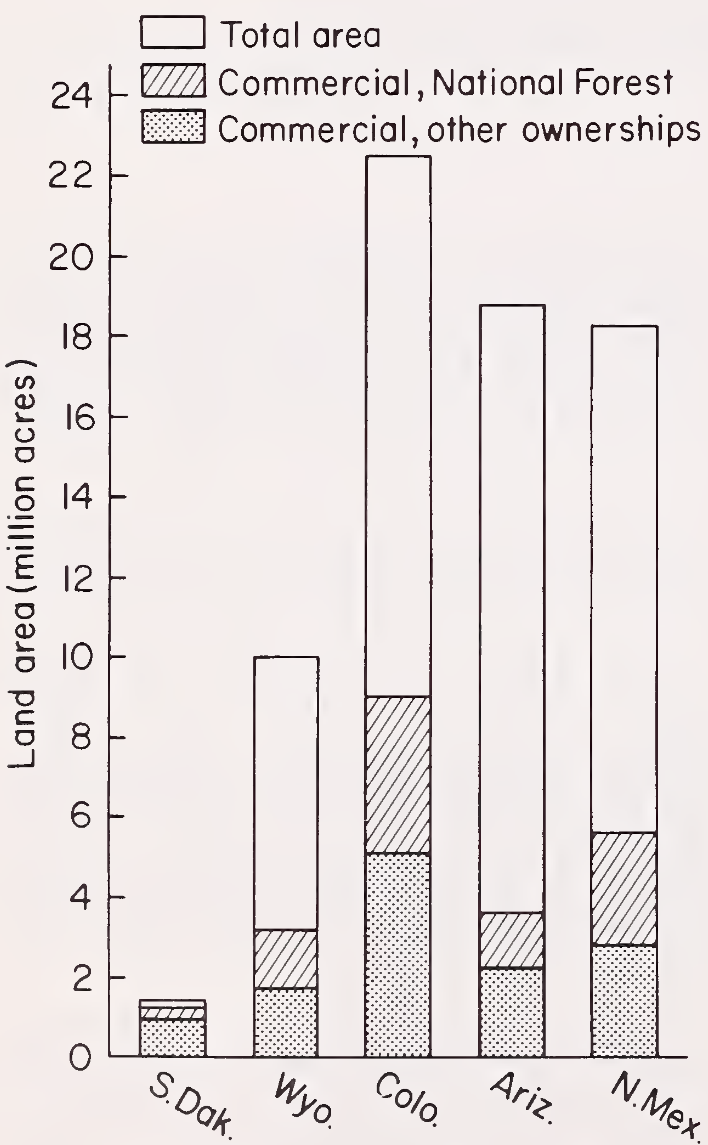

Figure 1.—Forest land area and commercial forest land area by state within study area. (Adapted from Green and Setzer 1974).

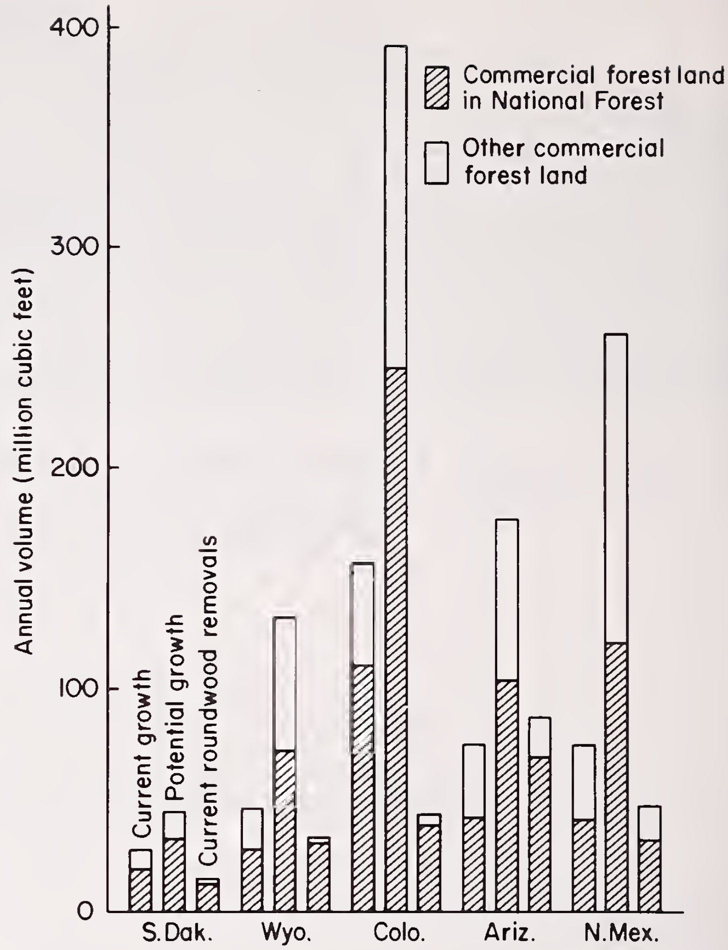

Figure 2.—Current annual growth, potential annual growth, and roundwood removals in 1974 by state. (Adapted from Green and Setzer 1974)

This does not mean we should forget about wood as an energy source. Wood has several significant advantages. It is a low sulfur fuel that can be burned for energy without very costly antipollution devices. A wood-fueled system also has less total emissions per unit of energy output than a system using physically cleaned coal or low sulfur western coal (Hall 1976). Another consideration is that pressure is growing rapidly to seek out and utilize all economical sources of energy. Wood's renewability, as compared with fossil fuels, is particularly attractive.

Table 1.—Typical heating values for wood and bark of Rocky Mountain species

Species	Heating value per dry pound	
	Wood	Bark
	BTU	*BTU*
Douglas fir	[1]9,200	[1]10,100
Lodgepole pine	[1]8,600	[1]10,760
Ponderosa pine	[1]9,100	[2] 9,100
Englemann spruce	—	[3] 8,820
True firs	[1]8,300	—

[1]*Dobie and Wright (1975)*
[2]*Grantham, et al. (1974)*
[3]*Corder (1973)*

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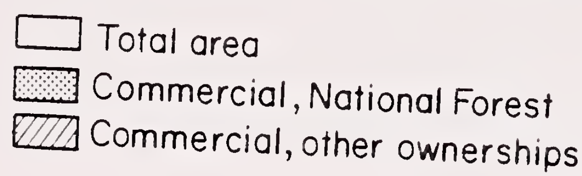

The remainder of this paper is a discussion of several parameters to help identify economic opportunities for utilizing wood for energy.

Economics of Using Wood as Fuel

For wood to be an economical choice as fuel, two economic tests must be met. First, wood must be a cheaper source of energy than competing fuels. Second, use of wood as a fuel must be more profitable than use of wood for other purposes.

Energy Potential of Timber

Volume of current removals of timber for energy generation purposes is not known. Most removals are probably for use in fireplaces with a very small amount for use in stoves. Much of the firewood from National Forests is removed under free-use arrangements, and there are no estimates of the volumes removed from other ownerships.

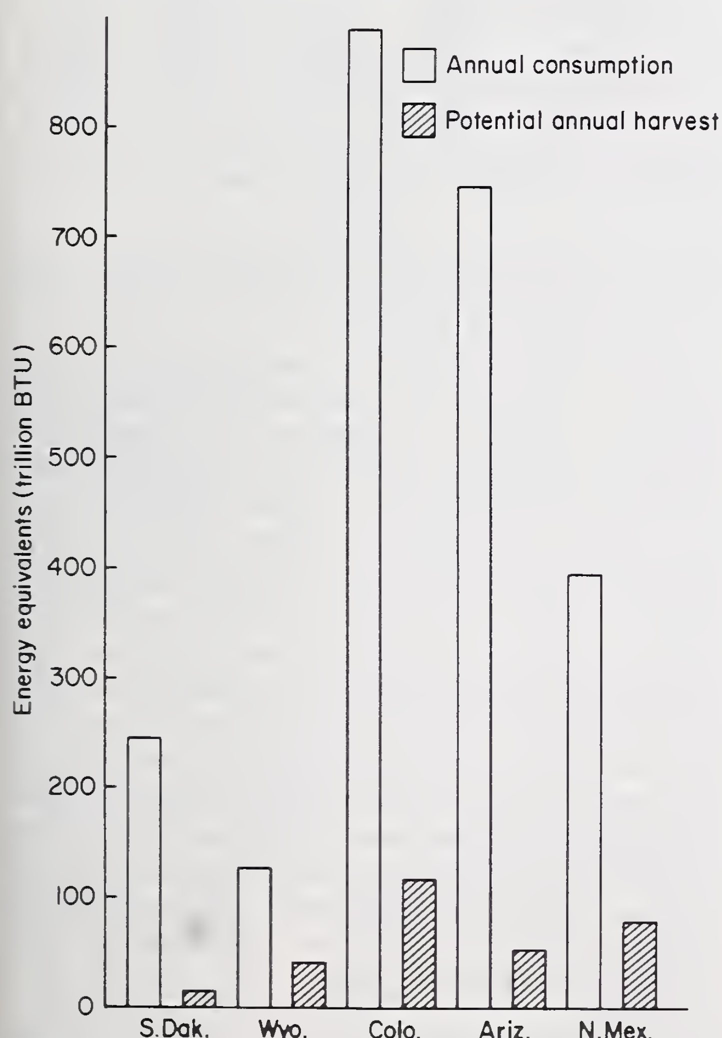

Figure 3.—Estimated annual consumption of energy (1973 data) and energy from potential annual timber harvest from commercial forest land. (Derived from population estimates and data in Baldwin et al. 1974)

For the Rocky Mountain area the major energy source competing with wood-based energy is coal. In terms of technology, coal and wood are interchangeable for energy generation. Therefore, the cost of wood and the environmental impact of its use relative to coal will determine if and where wood can be economically used as an energy source. The current delivered coal price for high volume users such as electric generating plants is $9 per ton ($9.92/metric ton) in the Black Hills and up to $16 per ton ($17.63/metric ton) in Colorado's Front Range. With conventional systems of timber harvesting in the Rocky Mountains, very little wood can be brought in at a comparable cost unless benefits to land management are included.

For example, based on Forest Service estimates the cost of getting Black Hills timber to a woods landing, excluding the cost of roads, brush disposal, and the like, would be about $7-$8 per green ton ($7.72-$8.82/metric ton). Costs of hauling to the energy conversion plant and any required handling or processing must be added to falling and yarding costs. Cost comparisons for accumulating wood and coal on a potential energy basis are shown in figure 4. Where the energy user is relatively close to a coal mine, coal will almost certainly be a cheaper fuel. Locations in the Rocky Mountains are close to both coal and timber; locations in New England are close to timber but far from coal. So in the Northeast, harvesting and burning timber may be an economically viable alternative for generating electricity, while the potential for harvesting timber in the Rocky Mountains for energy is less favorable due to the presence of cheaper energy sources.

Higher harvesting and hauling costs can be tolerated for other forest products than for energy. Timber value at a Rocky Mountain mill before processing is more than $120 per thousand board feet or about $50 per ovendry ton ($55.12/metric ton). This price is for the whole log, only one-third of which is likely to end up as lumber. Thus, that portion of the log that ends up as finished lumber is worth over $150 per ovendry ton ($165.35/metric ton). Current market prices for pulpwood, fence

posts, and poles also justify harvesting and transportation costs substantially higher than energy uses could sustain.

Future levels of use of timber for energy beyond what is used in fireplaces for esthetic purposes will depend on changes in technology which will allow harvesting of wood for energy at lower costs. Dramatic increases in alternative energy sources such as natural gas, fuel oil, and coal might also result in more timber being used for energy.

Energy Potential of Mill Residues

Residues from primary forest products provide a more economical source of energy from wood because harvesting and transportation costs are charged to the primary product. This usually makes mill residues a cheaper energy source than coal (and it is also cheaper than oil or natural gas if only variable costs of the fuels are considered). Mill residues can even be hauled short distances and still be cheaper than coal as shown in figure 4.

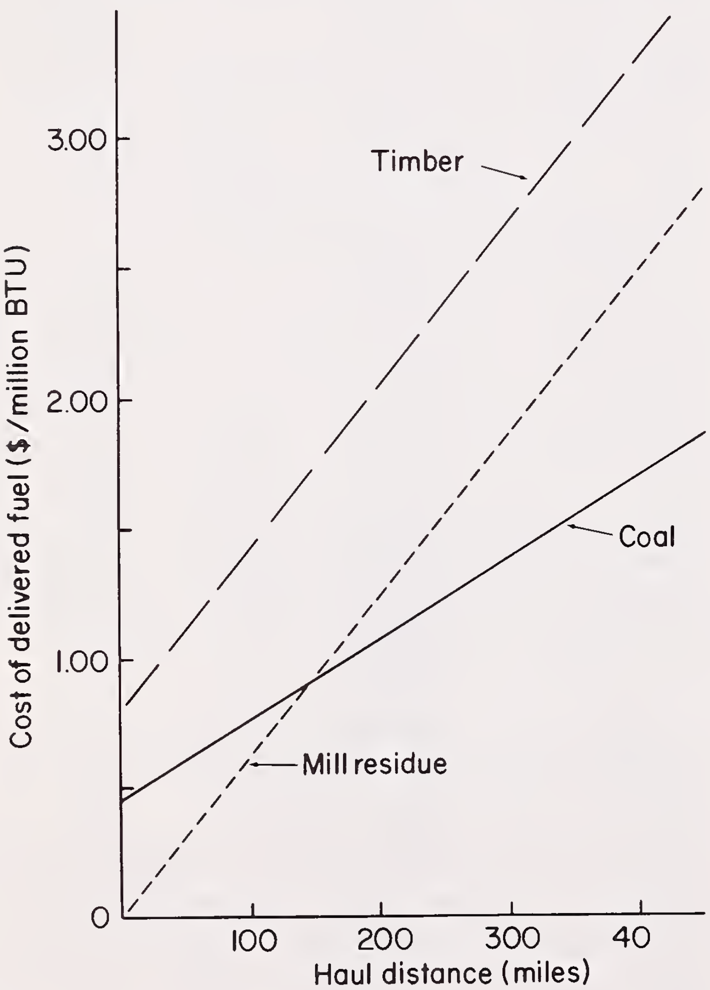

Figure 4.—Cost of energy from timber, coal, and forest products industry residue by haul distance. (Transportation cost of $0.0625 per ton-mile for all materials)

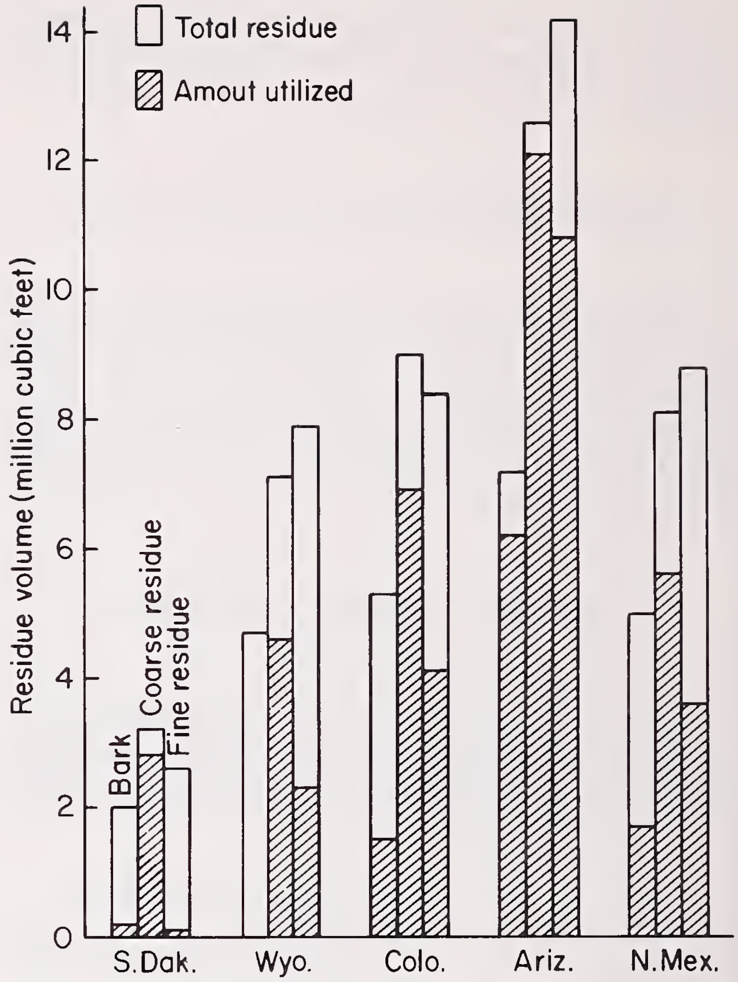

Figure 5.—Mill residues produced and utilized, by type, for each state.

The latest statistics on volume and use of mill residues in the central Rocky Mountains are shown by figure 5. With the exception of Wyoming, these data were collected through questionnaires for the year 1974 by the individual states in cooperation with the Intermountain Forest and Range Experiment Station (Setzer and Barrett 1977a and 1977b, Setzer and Shupe 1977, and Setzer and Throssell 1977). For Wyoming, estimates were from similar information for the year 1969 (Setzer 1971). The proportion of each type of residue that was being used is also shown (fig. 5). A greater proportion of mill residues is being utilized in Arizona than any other state. In all states, coarse residues are utilized to the greatest extent with bark and fine residues utilized in lesser amounts.

Uses being made of mill residues are many and varied. Although there are no data on where these residues are used, the greatest volume is probably used for pulp chips (from the coarse residues). The next largest use is

probably fuel for drying lumber, providing steam power, and heating sawmills. Most mills using wood residues for these purposes incorporate a boiler and steam heat. Two particleboard plants operating in New Mexico use mill residues as raw material. Other plants make a soil amendment from bark and a decorative bark mulch. Other mill residues are used for animal and poultry bedding. Present uses of mill residues for energy include fireplace logs, wood wafers, or briquettes.

What is the energy potential of mill residues that aren't used? Once the cost of harvesting and transporting timber to the mill has been charged to lumber or some other product, the residue becomes a relatively low-cost source of energy. The practicality of utilizing this inexpensive residue for energy rests on economies of scale and the level of unmet local energy demand. The most obvious demand, and one always present, is energy for the mill itself. Sawmills, for example, could be more than energy self-sufficient if all of their residues were used in-house. However, to date, the only move toward energy self-sufficiency by most mills in the central Rocky Mountains is in using residue to generate steam for kiln drying, to operate some machinery, and to heat the mill. Navajo Forest Products Industries in New Mexico has been generating electricity for mill use using mill residues for many years. Managers at two local mills have examined the potential for generating their own electricity but abandoned the idea due to unfavorable economics and problems of selling excess electricity. A recent Canadian study included findings that a mill or group of mills must process 150 million board feet of timber per year for electrical power generation from wood residues to be economically feasible (Canada Department of Environment 1975). However, a study just completed indicated electric energy generation from wood residue should be feasible for a much smaller wood products complex at the Fort Apache Indian Reservation in Arizona.[3] This facility is now being constructed. One central Rocky Mountain electric utility company is burning, on an experimental basis, sawdust mixed with coal.

Several major proposals are pending for additional utilization of mill residue and forest residue. In the Black Hills, several uses of wood for energy have been proposed, including a chemical recovery plant (ethanol), a wood gasification plant with the resulting gas being burned for heat, and a plant for direct firing of wood residue to produce heat or steam. Laramie, Wyo., has been investigated as a possible plant site by a firm which is pioneering a pyrolysis process that recovers gas, oil, and char from organic material. There is also a proposal to use wood residues as an energy source for drying potato waste and alfalfa in Colorado's San Luis Valley.

What, then, is the future for energy from mill residues in the central and southern Rocky Mountains? Mills having boilers for kiln drying or steam power will undoubtedly find this use has top priority for residues. After this allocation, any excess of mill residues should be available to the highest bidder. In many areas pulp chips have been the highest bidder. However, rising shipping costs are making pulp chips a less viable alternative in the Black Hills, Wyoming, and northern Colorado. Partly because of this, it is likely there will be at least one particleboard plant in the Black Hills in the next several years, and possibly one or more elsewhere in the central Rocky Mountains. Particleboard represents a higher economic use for mill residue than energy under most circumstances. There will likely remain substantial volumes of unutilized residues in scattered locations. Perhaps the most promising use of remaining residues is burning for domestic or for industrial heat or steam in conjunction with, or in lieu of, coal. This use may require further processing of the residue, such as hogging, drying, or densifying, depending on the type and location of the installation where the residue is to be used. As with other uses, the practicality of heating with mill residues depends on the cost of hauling the residues from where they are generated to where they are to be burned.

Large Scale Versus Small Scale Energy Use

A major enterprise set up solely for the purpose of producing commercial energy from timber or mill residue would have doubtful economic viability at this time. At this time there is a serious question whether any potential wood-based energy plant could be assured a long-term raw material supply. This is particularly true

[3]Personal communication with Milton Mater, president, Mater Engineering, Corvallis, Oreg.

for locations near National Forest lands where RARE II has halted harvesting on a large portion of the region's forests. This situation will be temporary for areas not selected for wilderness status and should be at least partially resolved in 1979. Fragmented ownership and uncertain or undefined management goals pose similar problems in the private sector and timber volumes harvested from these lands have been low in recent years.

More Efficient Harvesting

Improved harvesting methods could possibly make forest residues a more economical energy source than indicated previously (fig. 4). It may be possible to develop new harvesting systems to deliver the whole tree to the woods landing at or below current costs of harvesting bole wood. For example, full tree logging, where trees are felled and then skidded with limbs intact, could be used when the practice is environmentally acceptable. At the landing, trees could be more efficiently processed through a delimber which would also cut the boles into appropriate lengths. This would concentrate branches, tops, and foliage at the landing—essentially without added cost. The cost of chipping at the landing, which would likely have to be done to facilitate handling and transportation, would of course be additional, but brush piling and burning could be eliminated. This kind of situation is represented in figure 6 by the line labeled "Slash-A," which assumes a cost advantage amounting to $0.50 per green ton of slash ($0.55/green metric ton) was produced under the new system where brush disposal was eliminated. "Slash-A" also assumes a chipping cost of $3.50 per green ton ($3.86/green metric ton) at the landing.

Reduced hauling costs could be realized if the residues could be dried or otherwise processed to produce a greater energy content per unit of weight. For example, under assumptions the same as for "Slash-A," but if in addition the residue is dried and/or pelletized so that it can produce 8,000 BTU's per pound (18,608 kj/kg), we have the situation depicted by line "Slash-B." Such additional processing produces cost advantages if distances from the forest to point of use are great. However, complex activities like drying and/or densifying, or even chipping, cannot be carried out in the woods without

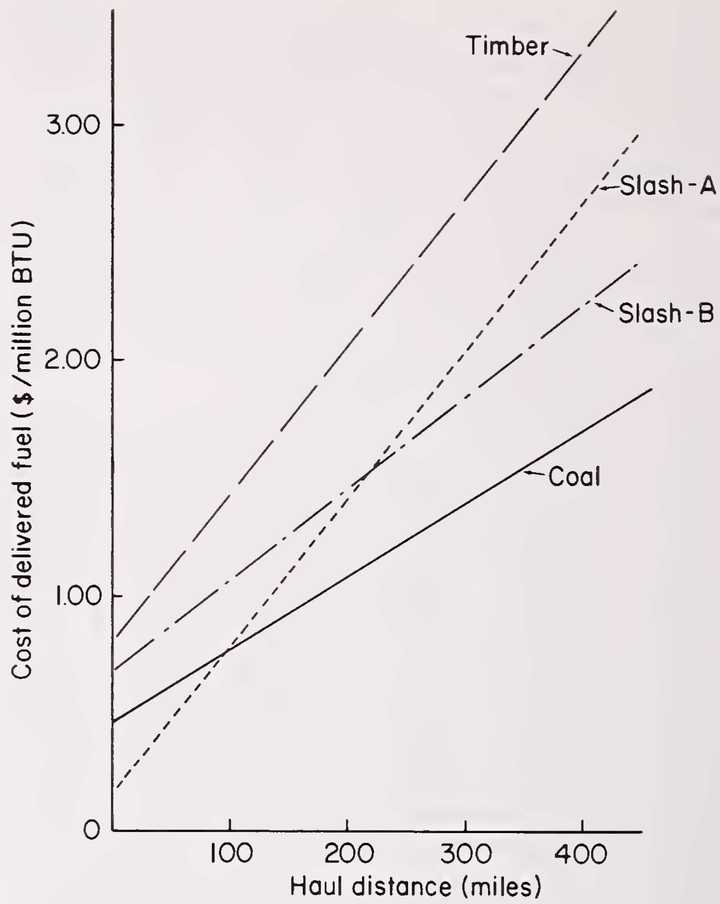

Figure 6.—Cost of energy from timber, coal, and two hypothetical improved harvesting systems by haul distance. (Transportation cost of $0.0625 per ton-mile for all materials)

problems. Very efficient technology and crew management are necessary to carry them out economically.

Despite the less than optimistic outlook for large volume uses of wood for energy in the Rocky Mountains, the outlook is good for selective residential, institutional, commercial, and industrial markets for wood fuel. Fossil fuel price increases could create a ready market for residues and facilitate forest management.

Homes, commercial establishments, and other low-volume energy users, which now use natural or propane gas or fuel oil, may not find switching to coal the most economical alternative. The coal cost estimates shown in figures 4 and 6 will not apply. To reach these users, coal would have to go through one or more wholesalers and incur additional handling costs. This would probably make pelletized wood or cordwood a more attractive alternative than coal, if locally available. However, a barrier to increased use of either wood or coal for heating homes, small commercial establishments, or institutions is lack of installed small-scale equipment for using these fuels. Development of

small-scale equipment that approaches oil or natural gas systems in automation and convenience would increase the demand for wood or coal as oil and natural gas prices increase.

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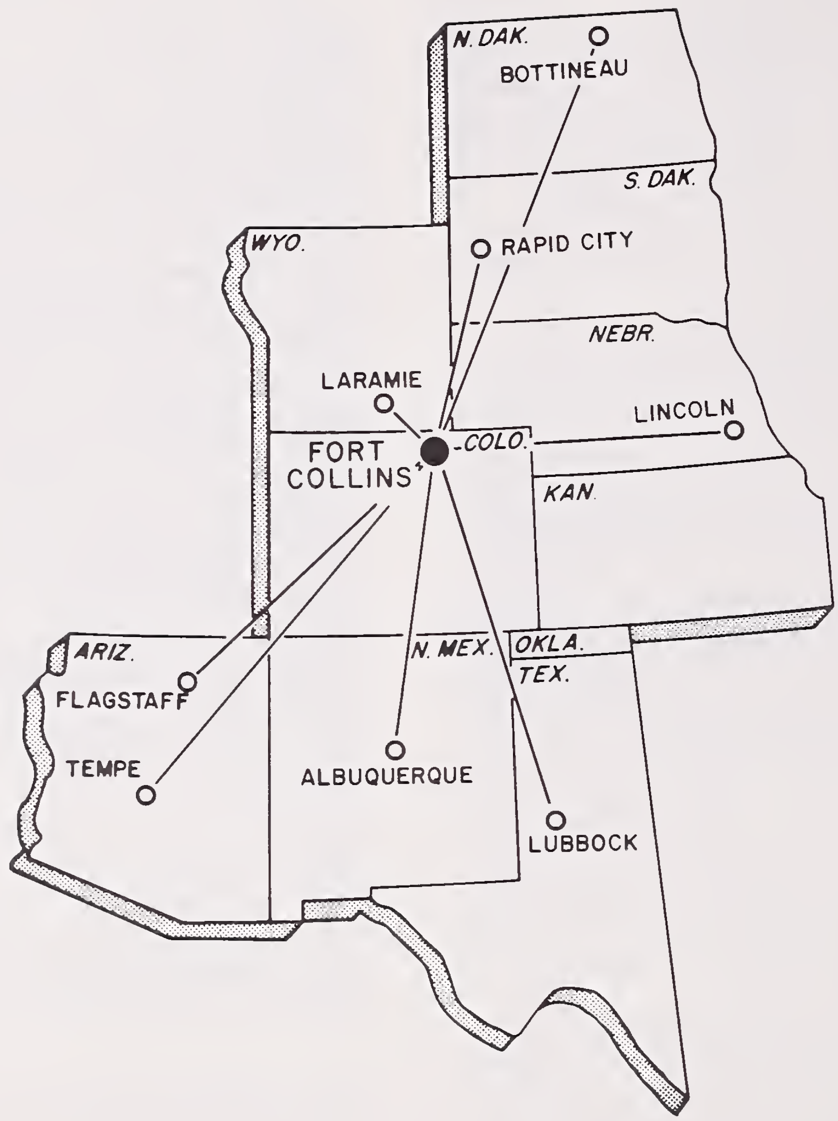
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